The Possibility of Past Life on Mars

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An igneous Mars meteorite, ALH84001, of unknown geologic context, was penetrated by fluids along fractures and pore spaces, which then became the sites of secondary mineral formation. Freshly broken fracture surfaces display carbonate globules with associated abundant polycyclic aromatic hydrocarbons (PAHs). Studies by others have shown that the igneous material crystalized 4.5 Ga, and that the carbonate globules formed 3.6 Ga. ALH84001 was removed from the martian surface 16 My ago by an impact and arrived on Antarctica 13,000 years ago. It appears to be essentially free of terrestrial weathering. The PAHs are present at concentrations $\sim 10^3$ to 10^5 times higher than are found in the surrounding terrestrial ice, and contamination studies indicate that the observed organic material is indigenous to the meteorite. The carbonate globules are rimmed by fine-grained, secondary phases of single-domain magnetite and iron sulfides, that could have resulted from oxidation and reduction reactions known to be important in terrestrial microbial systems. SEM and TEM images of the carbonate globules show features resembling terrestrial microorganisms, terrestrial biogenic carbonate structures, or microfossils. Although there are alternative explanations for each of the above phenomena taken individually, when they are considered collectively, particularly in view of their spatial association, we conclude that they may be evidence for primitive life on early Mars.

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